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II. *The Effects of Cold ; together with Observations of the Longitude, Latitude, and Declination of the Magnetic Needle, at Prince of Wales's Fort, upon Churchill-River in Hudson's Bay, North America ; by Capt. Christopher Middleton, F. R. S. Commander of His MAJESTY'S Ship Furnace, 1741-2.*

Read Oct. 28.
1742.

I Observed, that the *Hares, Rabbits, Foxes and Partridges*, in *September*, and the Beginning of *October*, changed their native Colour to a snowy White ; and that for Six Months, in the severest Part of the Winter, I never saw any but what were all white, except some *Foxes* of a different Sort, which were grizzled, and some half red, half white.

That Lakes and standing Waters, which are not above 10 or 12 Feet deep, are frozen to the Ground in Winter, and the Fishes therein all perish.

Yet in Rivers near the Sea, and Lakes of a greater Depth than 10 or 12 Feet, Fishes are caught all the Winter, by cutting Holes through the Ice down to the Water, and therein putting Lines and Hooks. But if they are to be taken with Nets, they cut several Holes in a strait Line the Length of the Net, and pass the Net, with a Stick fastened to the Head-line, from Hole to Hole, till it reaches the utmost Extent ; and what Fishes come to these Holes for Air, are thereby entangled in the Net ; and these Fish, as soon

as brought into the open Air, are instantaneously frozen as stiff as Stock-fish. The Seamen likewise freshen their salt Provisions, by cutting a large Hole through the Ice in the Stream or Tide of the River, which they do at the Beginning of the Winter, and keep it open all that Season. In this Hole they put their salt Meat, and the Minute it is immersed under Water, it becomes pliable and soft, though before its Immersion it was hard frozen.

Beef, Pork, Mutton, and Venison, that are killed at the Beginning of the Winter; are preserved by the Frost, for Six or Seven Months, intirely free from Putrefaction, and prove tolerable good eating. Likewise *Geese, Partridges*, and other Fowl, that are killed at the same time, and kept with their Feathers on, and Guts in, require no other Preservative but the Frost to make them good wholesome eating, as long as the Winter continues. All kinds of Fish are preserved in the like manner.

In large Lakes and Rivers, the Ice is sometimes broken by imprisoned Vapours; and the Rocks, Trees, Joists and Rafters of our Buildings, are burst with a Noise not less terrible than the firing off a great many Guns together. The Rocks which are split by the Frost, are heaved up in great Heaps, leaving large Cavities behind; which I take to be caused by imprisoned watery Vapours, that require more Room, when frozen, than they occupy in their fluid State. Neither do I think it unaccountable, that the Frost should be able to tear up Rocks and Trees, and split the Beams of our Houses, when I consider the great Force and Elasticity thereof. If Beer or Water is left in Mugs, Cans, Bottles, nay in Copper Pots, though they

they were put by our Bed-sides, in a severe Night they are surely split to pieces before Morning, not being able to withstand the expansive Force of the inclosed Ice.

The Air is filled with innumerable Particles of Ice, very sharp and angular, and plainly perceptible to the naked Eye. I have several times this Winter tried to make Observations of some celestial Bodies, particularly the Emerisions of the Satellites of *Jupiter*, with reflecting and refracting Telescopes; but the Metals and Glasses, by that Time I could fix them to the Object, were covered a quarter of an Inch thick with Ice, and thereby the Object rendered indistinct, so that it is not without great Difficulties that any Observations can be taken.

Bottles of *strong Beer, Brandy, strong Brine, Spirits of Wine*, set out in the open Air for Three or Four Hours, freeze to solid Ice. I have tried to get the Sun's Refraction here to every Degree above the Horizon, with *Elton's* Quadrant, but to no Purpose, for the Spirits froze almost as soon as brought into open Air.

The Frost is never out of the Ground, how deep we cannot be certain. We have dug down 10 or 12 Feet, and found the Earth hard frozen in the Two Summer Months; and what Moisture we find Five or Six Feet down, is white like Ice.

The Waters or Rivers near the Sea, where the Current of the Tide flows strong, do not freeze above Nine or Ten Feet deep.

All the Water we use for Cooking, Brewing, &c. is melted Snow and Ice; no Spring is yet found free from freezing, though dug never so deep down. All
Waters

Waters in-land are frozen fast by the Beginning of *October*, and continue so till the Middle of *May*.

The Walls of the House we live in are of Stone, Two Feet thick, the Windows very small, with thick wooden Shutters, which are close shut 18 Hours every Day in the Winter. There are Cellars under the House, wherein we put our *Wines, Brandy, strong Beer, Butter, Cheese, &c.* Four large Fires are made in great Stoves, built on purpose, every Day : As soon as the Wood is burnt down to a Coal, the Tops of the Chimneys are close stopped with an Iron Cover : This keeps the Heat within the House (though at the same time the Smoke makes our Heads ache, and is very offensive and unwholsome); notwithstanding which, in Four or Five Hours after the Fire is out, the Inside of the Walls of our House and Bed-places will be Two or Three Inches thick with Ice, which is every Morning cut away with a Hatcher. Three or Four times a Day we make Iron Shot of 24 Pounds Weight red-hot, and hang them up in the Windows of our Apartments. I have a good Fire in my Room the major Part of the 24 Hours, yet all this will not preserve my *Beer, Wine, Ink, &c.* from freezing.

For our Winter Drefs we make use of Three Pair of Socks of coarse Blanketting or Duffield for the Feet, with a Pair of *Deer-skin* Shoes over them ; Two Pair of thick *English* Stockings, and a Pair of Cloth Stockings upon them ; Breeches lined with Flannel ; Two or Three *English* Jackets, and a Fur or Leather Gown over them ; a large Beaver Cap, double, to come over the Face and Shoulders, and a Cloth of Blanketting under the Chin ; with Yarn Gloves, and

a large Pair of Beaver Mittings hanging down from the Shoulders before, to put our Hands in, which reach up as high as our Elbows; yet notwithstanding this warm Cloathing, almost every Day, some of the Men that stir abroad, if any Wind blows from the Northward, are dreadfully frozen; some have their Arms, Hands and Face blistered and frozen in a terrible manner, the Skin coming off soon after they enter a warm House, and some have lost their Toes. Now their lying-in for the Cure of these frozen Parts, brings on the Scurvy in a lamentable manner. Many have died of it, and few are free from that Distemper. I have procured them all the Helps I could, from the Diet this Country affords in Winter, such as fresh Fish, Partridges, Broths, &c. and the Doctors have used their utmost Skill in vain; for I find nothing will prevent that Distemper from being mortal, but Exercise and stirring abroad.

Coronæ and *Parbelia*, commonly called *Halo's*, and *Mock-Suns*, appear frequently about the Sun and Moon here. They are seen once or twice a Week about the Sun, and once or twice a Month about the Moon, for Four or Five Months in the Winter, several *Coronæ* of different Diameters appearing at the same time.

I have seen Five or Six parallel *Coronæ* concentric with the Sun several times in the Winter, being for the most-part very bright, and always attended with *Parbelia* or *Mock-Suns*. The *Parbelia* are always accompanied with *Coronæ*, if the Weather is clear; and continue for several Days together, from the Sun's Rising to his Setting. These Rings are of various Colours, and about 40 or 50 Degrees in Diameter.

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The frequent Appearance of these *Phænomena* in this frozen Clime seems to confirm *Descartes's* Hypothesis, who supposes them to proceed from Ice suspended in the Air.

The *Aurora Borealis* is much oftener seen here than in *England*; seldom a Night passes in the Winter free from their Appearance. They shine with a surprising Brightness, darkening all the Stars and Planets, and covering the whole Hemisphere: Their tremulous Motion from all Parts, the Beauty and Lustre, are much the same as in the Northern Parts of *Scotland* and *Denmark*, &c.

The dreadful long Winters here may almost be compared to the Polar Parts, where the Absence of the Sun continues for Six Months; the Air being perpetually chilled and frozen by the Northerly Winds in Winter, and the cold Fogs and Mists obstructing the Sun's Beams in the short Summer we have here; for notwithstanding the Snow and Ice is then dissolved in the Low-lands and Plains, yet the Mountains are perpetually covered with Snow, and incredible large Bodies of Ice continue in the adjacent Seas. If the Air blows from the Southern Parts, the Air is tolerably warm, but very cold when it comes from the Northward, and it seldom blows otherwise than between the North-east and North-west, except in the Two Summer Months, when we have, for the major Part, light Gales between the East and the North, and Calms.

The Northerly Winds being so extremely cold, is owing to the Neighbourhood of high Mountains, whose Tops are perpetually covered with Snow, which exceedingly chills the Air passing over them.

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The Fogs and Mists that are brought here from the Polar Parts, in Winter, appear visible to the naked Eye in Icicles innumerable, as small as fine Hairs or Threads, and pointed as sharp as Needles. These Icicles lodge in our Cloaths, and if our Faces or Hands be uncovered, they presently raise Blisters as white as a Linen Cloth, and as hard as Horn. Yet if we immediately turn our Backs to the Weather, and can bear our Hand out of our Mittin, and with it rub the blistered Part for a small time, we sometimes bring the Skin to its former State: If not, we make the best of our Way to a Fire, and get warm Water, where-with we bathe it, and thereby dissipate the Humours raised by the frozen Air; otherwise the Skin would be off in a short time, with much hot, ferous, watry Matter coming from under along with the Skin; and this happens to some almost every time they go abroad for Five or Six Months in the Winter, so extreme cold is the Air when the Wind blows any thing strong.

Now I have observed, that when it has been extreme hard Frost by the Thermometer, and little or no Wind that Day, the Cold has not near so sensibly affected us, as when the Thermometer has shewed much less freezing, having a brisk Gale of Northerly Wind at the same time. This Difference may perhaps be occasioned by those sharp-pointed Icicles before-mentioned striking more forcibly in a windy Day, than in calm Weather, thereby penetrating the naked Skin, or Parts but thinly covered, and causing an acute Sensation of Pain or Cold: And the same Reason, I think, will hold good in other Places; for should the Wind blow Northerly any thing hard for

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many Days together in *England*, the Icicles that would be brought from the Polar Parts by the Continuance of such a Wind, though imperceptible to the naked Eye, would more sensibly affect the naked Skin, or Parts but slightly covered, than when the Thermometer has shewn a greater Degree of freezing, and there has been little or no Wind at the same time.

It is not a little surprising to many, that such extreme Cold should be felt in these Parts of *America*, more than in Places of the same Latitude on the Coast of *Norway*; but the Difference I take to be occasioned by Wind blowing constantly here, for Seven Months in the Twelve, between the North-east and North-west, and passing over a large Tract of Land, and exceeding high Mountains, &c. as before-mentioned. Whereas at *Drunton* in *Norway*, as I observed some Years ago in wintering there, the Wind all the Winter comes from the North and North North-west, and crosses a great Part of the Ocean clear of those large Bodies of Ice we find here perpetually. At this Place we have constantly every Year Nine Months Frost and Snow, and unsufferable Cold from *October* till the Beginning of *May*. In the long Winter, as the Air becomes less ponderous towards the Polar Parts, and nearer to an *Equilibrium*, as it happens about One Day in a Week, we then have Calms and light Airs all round the Compass, continuing sometimes 24 Hours, and then back to its old Place again, in the same manner as it happens every Night in the *West-Indies*, near some of the Islands.

The Snow that falls here is as fine as Dust, but never any Hail, except at the Beginning and End of Winter. Almost every Full and Change of the Moon, very hard Gales from the North.

The constant Trade Winds in these Northern Parts I think undoubtedly to proceed from the same Principle, which our learned Dr. *Halley* conceives to be the Cause of the Trade Winds near the Equator, and their Variations.

“ Wind, says he, is most properly defined to be
 “ the Stream or Current of the Air; and where such
 “ Current is perpetual and fixed in its Course, it is
 “ necessary, that it proceed from a permanent and
 “ unintermitting Cause, capable of producing a like
 “ constant Effect, and agreeable to the known Pro-
 “ perties of Air and Water, and the Laws of Motion
 “ of fluid Bodies. Such an one is, I conceive, the
 “ Action of the Sun’s Beams upon the Air and Wa-
 “ ter, as he passes every Day over the Oceans, consi-
 “ dered together with the Nature of the Soil and
 “ Situation of the adjoining Continents. I say,
 “ therefore, first, That according to the Laws of
 “ *Statics*, the Air which is less rarefied or expanded
 “ by Heat, and consequently more ponderous, must
 “ have a Motion towards those Parts thereof which
 “ are more rarefied, and less ponderous, to bring it to
 “ an *Equilibrium*, &c.”

Now, that the cold dense Air, by reason of its great Gravity, continually presses from the Polar Parts towards the Equator, where the Air is more rarefied, to preserve an *Equilibrium* or Balance of the Atmosphere, I think, is very evident from the Wind in those frozen Regions blowing from the North and

North-west, from the Beginning of *October* until *May*; for we find, that when the Sun, at the Beginning of *June*, has warmed those Countries to the Northward, then the South-east, East and variable Winds continue till *October* again; and I do not doubt but the Trade Winds and hard Gales may be found in the Southern Polar Parts to blow towards the Equator, when the Sun is in the Northern Signs, from the same Principle.

The Limit of these Winds from the Polar Parts, towards the Equator, is seldom known to reach beyond the 30th Degree of Latitude; and the nearer they approach to that Limit, the shorter is the Continuance of those Winds. In *New-England* it blows from the North near Four Months in the Winter; at *Canada*, about Five Months; at the *Danes* Settlement in *Streights Davis*, in the 63d Degree of Latitude, near Seven Months; on the Coast of *Norway*, in 64, not above Five Months and a half, by reason of blowing over a great Part of the Ocean, as was before-mentioned; for those Northerly Winds continue a longer or shorter Space of Time, according to the Air's being more or less rarefied, which may very probably be altered several Degrees, by the Nature of the Soil, and the Situation of the adjoining Continents.

The vast Bodies of Ice we meet with in our Passage from *England* to *Hudson's-Bay*, are very surprising, not only as to Quantity, but Magnitude, and as unaccountable how they are formed of so great a Bulk, some of them being immersed 100 Fathom or more under the Surface of the Ocean; and a Fifth or Sixth Part above, and Three or Four Miles in Circumference.

cumference. Some Hundreds of these we sometimes see in our Voyage here, all in Sight at once, if the Weather is clear. Some of them are frequently seen on the Coasts and Banks of *Newfoundland* and *New-England*, though much diminished.

When I have been becalmed in *Hudson's-Streights* for Three or Four Tides together, I have taken my Boat, and laid close to the Side of one of them, sounded, and found 100 Fathom Water all round it. The Tide floweth here above Four Fathom; and I have observed, by Marks upon a Body of Ice, the Tide to rise and fall that Difference, which was a Certainty of its being aground. Likewise, in a Harbour in the Island of *Resolution*, where I continued Four Days, Three of these Isles of Ice (as we call them) came aground. I sounded along by the Side of one of them, quite round it, and found 32 Fathom Water, and the Height above the Surface but 10 Yards; another was 28 Fathom under, and the perpendicular Height but Nine Yards above the Water.

I can in no other manner account for the Aggregation of such large Bodies of Ice but this: All along the Coasts of *Streights Davis*, both Sides of *Baffin's-Bay*, *Hudson's-Streights*, *Anticosh*, or *Labradore*, the Land is very high and bold, and 100 Fathoms, or more, close to the Shore. These Shores have many Inlets or Fairs, the Cavities of which are filled up with Ice and Snow, by the almost perpetual Winters there, and frozen to the Ground, increasing for Four, Five, or Seven Years, till a kind of Deluge or Land-flood, which commonly happens in that Space of Time throughout those Parts, breaks them loose, and launches them into the Streights or Ocean, where they
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are driven about by the variable Winds and Currents in the Months of *June*, *July*, and *August*, rather increasing than diminishing in Bulk, being surrounded (except in Four or Five Points of the Compass) with smaller Ice for many Hundred Leagues, and Land covered all the Year with Snow, the Weather being extreme cold, for the most part, in those Summer Months. The smaller Ice that almost fills the Streights and Bays, and covers many Leagues out into the Ocean along the Coast, is from Four to Ten Fathom thick, and chills the Air to that Degree, that there is a constant Increase to the large Isles by the Sea's washing against them, and the perpetual wet Fogs, like small Rain, freezing as they settle upon the Ice ; and their being so deeply immersed under Water, and such a small Part above, prevents the Wind's having much Power to move them : For though it blows from the North-west Quarter near Nine Months in Twelve, and consequently those Isles are driven towards a warmer Climate, yet the progressive Motion is so slow, that it must take up many Years before they can get Five or Six hundred Leagues to the Southward ; I am of Opinion some Hundreds of Years are required ; for they cannot, I think, dissolve before they come between the 50th and 40th Degree of Latitude, where the Heat of the Sun consuming the upper Parts, they lighten and waste in Time : Yet there is a perpetual Supply from the Northern Parts, which will so continue as long as it pleases the AUTHOR of all Beings to keep things in their present State.

*Observations of the Longitude, Latitude, and
the Declination of the Magnetic Needle, at
Prince of Wales's Fort, Churchill-River.*

Having observed the apparent Time
of an Emerfion of *Jupiter's* first Sa-
tellite at *Fort-Churchill*, on *Saturday*
the 20th of *March* laſt 1741-2. at

h. ' "
11 55 50

I find the ſame Emerfion happened
at *London*, by Mr. *Pound's* Tables,
compared with ſome Emerfions actually
observed in *England* near the ſame, at

18 15 10

Whence the hoary Difference of
Meridians, between *Fort-Churchill* and
London, comes out

6 19 20

Which converted into Degrees of
the Equator, gives for the Diſtance of
the ſame Meridians

94° 50'

Wherefore, ſince the Time at *London* was later in
Denomination than that at *Churchill*, it follows that,
according to this Obſervation, *Churchill* is 94 De-
grees 50 Minutes, in Longitude Weſt of *London*.

I took ſeveral other Obſervations, which agreed
one with another to leſs than a Minute, but this I
look upon as the moſt diſtinct and beſt.

The Obſervation was made with a good 15 Foot
refracting Teſcope, and a Two Foot Reflector of
Gregory's Kind, having a good Watch of Mr. *Gra-*
ham's that I could depend upon; for I have frequent
Opportunities of diſcovering how much its Vari-
ation amounted to, and conſtantly found its daily
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Deviation or Error to be 15 Seconds too flow; by which means it was as useful to me for all Purposes, as if it had gone most constantly true without any Change. This Watch I kept in my Fob in the Day, and in Bed in the Night, to preserve it from the Severity of the Weather; for I observed, that all other Watches were spoiled by the extreme Cold.

I have found, from repeated Observations, a Method of obtaining the true Time of the Day at Sea, by taking Eight or Ten different Altitudes of the Sun or Stars, when near the Prime Vertical, by Mr. *Smith's* or Mr. *Hadley's* Quadrant, which I have practised these Three or Four Years past, and never found from the Calculations, that they differed one from another more than 10 or 15 Seconds of Time. This Certainty of the true Time at Sea is of greater Use in the Practice of Navigation, than may appear at first Sight; for you thereby not only get the Variation of the Compass without the Help of Altitudes, but likewise the Variation of the Needle from the true Meridian, every time the Sun or Star is seen to transit the same. Also having the true Time of Day or Night, you may be sure of the Meridian Altitude of the Sun or Star, if you get a Sight 15 or 20 Minutes before or after it passes the Meridian; and the Latitude may be obtained to less than Five Minutes, with several other Uses in Astronomical Observations; as the Refraction of the Atmosphere, and to allow for it, by getting the Sun's apparent Rising and Setting, which any body is capable of doing, and from thence you will have the Refraction.

If we had such a Telescope contrived as Mr. *Smith* recommends to be used on Shipboard at Sea, now we can have an exact Knowledge of the true Time of
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the Day or Night from the above Instruments and a good Watch, I hope we should be able to observe the Eclipses of the first *Satellite* of *Jupiter*, or any other *Phænomenon* of the like Kind, and thereby find the Distance of Meridians, or Longitude at Sea.

The Variation of the Magnetical Needle, or Sea-Compass, observed by me at *Churchill* in 1725. (as in N^o 393. of the *Philosophical Transactions* for the Months of *March* and *April* 1726.) was at that Time North 21 Degrees Westerly, and this Winter I have carefully observed it at the same Place, and find it no more than 17 Degrees, so that it has differed about One Degree in Four Years; for in 1738. I observed it here, and found its Declination 18 Degrees Westerly. I have carefully observed, and made proper Allowance for the Sun's Declination and Refraction, and find the Latitude here to be 58 Degrees 56 Minutes North: But in most Parts of the World, where the Latitudes are fixed by Seamen, they are for the most part falsely laid down, for want of having regard to the Variation of the Sun's Declination, which, computed at a distant Meridian, when the Sun is near the Equator, may make a great Error in the Sun's rising and setting *Azimuths*, &c.

These things I thought proper to take Notice of, as they may be of Service to Navigators, and the Curious in Natural Inquiries.

The foregoing Relation having been given by Capt. *Middleton* to the late worthy President of the ROYAL SOCIETY, Sir *Hans Sloane*, Bart. he was pleased to communicate the same to the SOCIETY, and at the same time, as the surviving Trustee of the late Sir *Godfrey Copley*, to nominate Capt. *Middleton* to receive this Year the Prize Medal, given annually by the ROYAL SOCIETY, in Consequence of Sir *Godfrey's* Benefaction; and the same was accordingly presented to the Captain on St. *Andrew's* Day last, 1742.